THE GROWTH AND DEVELOPMENT OF OATS

A Production Guide

Provided to our suppliers by:

GRAIN MILLERS


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The Growth and Development of Oats

GRAIN MILLERS

A Guide to Food Grade Oat Production

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Disclaimer

The Oat Production Guide published by Grain Millers, Inc. is a reference tool for growers in the upper Midwest of the United States and the Canadian Prairies. The information within the Guide is believed to be accurate and complete as of January 1, 2016. However, the Guide is designed for informational purposes only and Grain Millers, Inc. makes no representation, warranty, or guarantee that the information is accurate or that desirable results will always be obtained if the Guide is followed. Use of the Guide is at the sole risk of the grower. Grain Millers, Inc. and its affiliates shall not be liable for any damages, losses, or claims arising out of the use of the Guide, regardless of the legal theory utilized to make any such claim.

Overview

Since 1986, Grain Millers, Inc. has been a leading manufacturer of whole grain ingredients used in cereals, breads, bars, snacks and many other food products served around the world. The last 30 years have seen significant growth and expansion of our company. This continued expansion requires the support of our growers through the production of a food grade oat crop.

Food grade oats are grains that are destined to become an ingredient for human consumption. It is important that we buy "an ingredient" and not a commodity. This is the reason for our strict specifications for food grade oats which are shown in Appendix II. These oats need to be clean with plump, high test weight kernels.

Over the years we have been approached many times by growers asking what needs to be done to produce food grade oats. In an effort to help growers meet these needs Grain Millers started a crop sciences group in 2012. This group is dedicated toward helping farmers produce a crop of the greatest quality and quantity. It is important that growers are able to produce the best crop and ingredient. This Guide is designed to be used as a resource for growers to help them achieve these quality specifications and goals.

Updates

It is our goal as a company to continually update this Guide with any new and upcoming information. Updates, when available, will be published near January 1st, on an annual basis. To ensure your information is up-to-date, contact a Grain Millers Crop Science or Procurement representative.

Field Selection

There are multiple things to consider when selecting a field for oat production. This guide covers some of the important items but there will always be additional factors to consider.

Field selection is an important step to growing a successful oat crop. Oats should not be placed on marginal pieces of land and be expected to perform well. They should receive the same respect and attention that any other crop would receive. Proper management will provide the best potential for maximum return.

Fields relatively free of wild oats should be selected as wild oats are hard to remove through mechanical and chemical controls. Lack of control of wild oats will lead to a reduction in final grain quality. Please refer to Grain Millers Quality Specifications to determine the allowable level of wild oats. Use careful consideration before applying herbicides if oats are to follow in the rotation. Minimal or no herbicide residue carryover is best; herbicide residue can diminish germination of the crop as well as grain quality attributes. Other crops within the rotation on a field are important when making this decision. Oats, if possible, should not be rotated back to back with other cereal grains. Back to back rotation with other cereal grains increases the risk of plant disease and weed pressure. More desirable rotational crops include: canola, hayfields, soybeans, and/or other legumes. These crops give oats a strong potential by providing nutrients and reducing disease risk. Corn falls between the desirable rotational crops and the cereal grains. Corn can increase the risk of some plant diseases and tie up nitrogen early in the season.

Fields with early access should be chosen; planting oats early typically provides production and grain quality benefits later in the season.

Seed Selection

Seed selection is one of the most important considerations in producing oats of maximum quality and top yield. Growing oats, just like other crops, starts with planting quality seed and using the right varieties for the conditions. There are many factors to consider when selecting seed including: region, climate, soil type, disease pressure, previous crop and variety. Varieties differ in many characteristics including: yield potential, lodging resistance, test weight, groat percentage, hull color, maturity, and disease resistance. It is best to make variety decisions based on a combination of recommended varieties and available trial data. Grain Millers recommends planting certified seed to ensure purity, germination, viability, and overall quality.

See Appendix I for the Grain Millers, Inc. Preferred Variety lists.

Maturity

Maturity has two different effects on yield. The first is overall grain yield potential. Later varieties tend to have greater yield potential. The second effect maturity has on yield is when grain fill takes place. Later varieties will generally exhibit grain fill during later periods and in southern growing areas this may have a large effect on yield and test weight. Hot weather (temps above 90ºF or 32ºC) can cause a reduction in test weight and can enhance a condition called blasting. Blasting is the abortion of kernels that the plant can't support under adverse conditions.

Grain Millers categorizes oats into three different maturity groups for US varieties: Early, Medium, and Late. The maturity difference from the earliest to the latest variety is about 10 days.

Disease Resistance

Disease pressure can have significant negative effects on yield and test weight. Disease resistance can help promote strong crop potential as it reduces the stress that the plant endures. Most new oat varieties have been bred to show resistance towards three major diseases. These include two fungal diseases, Crown and Stem

Rust, and one virus, Barley Yellow Dwarf (BYDV). In addition to selecting resistant varieties, damage from Crown and Stem Rust can be reduced with fungicides. BYDV is transmitted by aphids and kills important plant tissue during the season. More information is available on these diseases in the Plant Disease section of this guide.

Hull Color

When considering the quality of oats for the food industry, the color of the hull has little to no impact. The food industry has little concern for the hull color as long as the groats are large, clean, and uniform.

Lodging Resistance

Lodging increases harvest problems and can reduce grain yield and quality. Growing conditions, soil nutrient levels, and varietal characteristics all impact the plant's resistance to lodging. Over-fertilizing can cause oats to grow tall and lodge. Selecting a shorter variety and/or one with greater straw strength can reduce the risk of lodging.

Planting

Spring oat varieties should be planted early in the season to provide an edge against weeds and weather. To facilitate early planting, seedbed preparation should be planned during the previous year. Fall tillage can help heavy soil warm and dry faster in the spring. Oats can tolerate cooler and wetter soils than many other crops and can germinate at soil temps as low as 45°F or 7°C. [1] Oat seeding normally starts early to mid-March in parts of Iowa through mid-June in northern oat growing regions. Early planting can help provide production benefits later in the season. Late planting will push grain fill into warmer weather periods which can reduce yield and test weight.

[1]Peterson, David. "Chapter 4." *Oat Science and Technology.* 1st ed. N.p.: ASA/CSSA, 1992. 81. Print

Oats should best be planted in narrow rows of about 6-7 inches to help reduce tillering and improve weed competition. Oats should not be planted more than 2 inches deep. The soil should be relatively free of clumps to help promote good seed to soil contact. Planting depth will vary with soil moisture and type.

The planting rate per acre is important to optimize yield and quality potential. The goal of the seeding rate is to provide a final stand of 18-25 plants per square foot. A heavier rate may help suppress weeds and reduce tillering, but one must be careful not to overdo it. While it is true that because of advancements in kernel size, many farmers err on the side of seeding at rates that are slightly too low, seeding at rates too high for soil type and fertility will result in poor yields and quality.

For conventional cropping systems, seed treatements ma,y be sued to prevent seedborne disease and/or insect pressure from hindering seedling vigor and plant and root development. As with any chemical application, use only products registered for use on oats and apply in accordance with label instructions.

Ideally, it is important to calculate the seeding rate using the formula below because individual kernel size can vary greatly among varieties and crop years. Calculating the seeding rate in this fashion ensures an optimal plant population which reduces tillering and improves yield and quality. To accurately calculate seeding rate, use seeds per pound and the following formula:

$$\text{Seeding Rate (lbs/acre)} = \frac{\{\text{Desired Stand} \div (1 - \text{Expected Stand Loss})\}}{(\text{Seeds/lb.}) \times (\text{\% Seed Germination})}$$

Expected stand loss is used in a decimal form (10 percent = 0.1)
"Desired Stand" is defined as plants per acre

Wiersma, J. J., and J. K. Ransom. *The Small Grains Field Guide*. N.p.: U of MN Extension, 2005. Print.

18 plants/square ft. = 784,080 plants/acre
19 plants/square ft. = 827,640 plants/acre
20 plants/square ft. = 871,200 plants/acre

Fertility and Fertilization

Soil Fertility

The nutrient requirements for oats are generally lower than many other crops. The oats plant is known to be a scavenger of nutrients because of its deep and fibrous root system. However, a balanced fertility program is imperative for optimal yields and grain quality. Soil testing is recommended to help determine needs to produce the best possible crop.

As shown in the table below, a 100 bushel per acre grain crop will take about 73lbs of nitrogen per acre. It is recommended for the soil nitrate test to have at least 120lbs/A in the top 2 feet of soil. Phosphorous (P_2O_5), potassium (K_2O), sulfur (S), and magnesium (Mg) are used in smaller amounts within oat production but are just as important. The levels in the table are the bare minimum, to promote higher yields be sure to increase nutrient levels within the soil in a balanced formulation.

Application of fertilizer can be done in the fall or spring. If applying fertilizer in the fall be sure to do so after soil temperature has decreased below 50ºF or 10ºC as this will help limit nitrogen loss.

Crop	Yield (A)	N	P_2O_5	K_2O	Mg	S
Alfalfa	8 ton	408	96	392	43	43
Barley	120 bu.	166	67	182	17	23
Canola	60 bu.	180	90	150	37	30
Corn	150 bu.	135	57	41	14	12
Oats	**100 bu.**	**73**	**27**	**18**	**4**	**7**
Wheat	80-bu.	120	48	27	12	8

Nutrient levels reflect minimum plant requirement for grain production

Nitrogen

Nitrogen (N) is one of the five macronutrients that are imperative for a successful oat crop. Nitrogen is a crucial part of all plants chlorophyll structure and a base element of plant DNA and RNA. The level of N in the soil is important as problems can occur with both excess and deficient levels.

Deficiency- Plants that are deficient in N will exhibit a pale green/yellow color. They may also have a stunted appearance. The color is due to nitrogen's role in chlorophyll development and stunting is caused by the reduction in light uptake which is a vital part of photosynthesis. Deficiencies will typically be noticed first in the lower leaves of the plant starting at the midrib extending to the leaf edge. N is mobile within the plant which means it will scavenge N from older tissue to promote new tissue growth.

Excess – Extra N uptake by the plant will stimulate vegetative growth through elevated rates of photosynthesis. This can lead to lodging, increased disease susceptibility, and delays in maturity.

Plant Requirements

When looking to produce an oat crop of 100 bushels per acre nitrogen requirements are at least 73lbs of N per acre. This means that the oat crop will remove 73lbs of N from the soil during the production of this crop. A higher yield will require addition N per acre. It is recommended to add enough N for available levels in the top 2 feet of the soil to greater than 120 lbs.

Phosphorus

Phosphorus (P or applied as P_2O_5) is the macronutrient with the second highest rate of consumption in oat production. Phosphorus is important for plant metabolism; it is a part of ATP and ADP used in energy conversions. It is also important in the structural pieces of cell membranes. Adequate levels are important; deficiencies will affect crop production more than an excess of nutrients.

Deficiency – Plants that are P deficient will show multiple symptoms. These include stunted growth, poor root development, delays in maturity, dark green color, or purple discoloration. Symptoms can be more general through the plant unlike N and K which are seen first in older vegetation.

Excess – High levels of P are not directly harmful to plants. High levels of P can create a zinc deficiency.

Plant Requirements
Grain requirements of phosphorus are expressed in the form lbs. of P_2O_5 per acre. The minimum a 100bu crop will take from the soil is 27lbs/A. It is important to consult a soil test before adding P_2O_5 to the soil. If soil levels are above the 50 lbs/A it may not be necessary to add phosphorus fertilizer.

"Phosphorus Fertilizer Application in Crop Production." Alberta Agriculture and Forestry. Web.

Potassium
Potassium requirements for grain are low. A 100bu. crop will remove a minimum of 18lbs/A of K_2O. However, the plant removes much more than that from the soil and sequesters much of it in the straw. If the straw is left on the field, much of that will be returned to soil. If the straw is removed from the field, the same crop will remove about 100lbs/A of K_2O.

Deficiency – Potassium deficiencies will be fairly evident in oat plants. They will be seen first in the older and lower leaves with symptoms of chlorosis on leaf tips or edges. Deficiencies may also cause reduced stress tolerance, reduced disease resistance or increased lodging.

Excess – The main concerns that high potassium uptake would bring are magnesium and calcium deficiencies.

Plant Requirements
Potassium requirements for grain are low. A 100bu. crop will take out a minimum of 18lbs/A of K_2O. Straw removal requires much larger amounts of K_2O. If the straw is removed from the field the same crop will use about 100lbs/A of K_2O. Potassium ammendments may not be needed if soil test levels are above the 250 lbs/A.

"Potassium Fertilization in Crop Production." *Soils, Fertility and Nutrients.* Government of Saskatchewan, Dec. 2012. Web.

Sulfur (Sulphur)
Sulfur (S) is the first of the secondary macronutrients that are needed in an elevated amount. S is primarily used in the essential amino acids of the plant. When producing oats in rotation with crops of high sulfur utilization, such as canola, take extra care to ensure proper levels.

Deficiency – Symptoms will usually be visible on the upper or younger vegetation. It also may occur evenly over the entire plant. Symptoms will include chlorosis of the younger leaves, or stunted growth.

Plant Requirements
Sulfur will be removed from the soil at a rate of about 7lbs/A for the production of 100bu. of grain. If straw is being removed a greater reduction will occur.

Magnesium
The magnesium (Mg) requirement for an oat crop is similar to that of sulfur. Mg is crucial for photosynthesis as it is part of the chlorophyll molecule and is needed in protein synthesis.

Deficiency – Symptoms will occur first on the older and lower leaves of the plant. These symptoms will include inter-veinal chlorosis. That means the area around leaf veins will still be green but all other areas will be yellow.

Excess – Large amounts of the Mg in the soil will not be toxic to plants. Although high amounts can reduce uptake of potassium (K) or calcium(Ca).

Plant Requirements
Magnesium will be removed from the soil at a rate of about 4lbs/A for the production of 100bu. of grain. If straw is being removed a greater reduction will occur.

Integrated Pest Management

Weeds, diseases, and insects can take a major toll on crop production. Integrated pest management is an important plan to help control the major pests that affect oats. The University of California, Davis does an excellent job creating a strong definition:

"Integrated pest management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment."

"University of California." *Technical Definition of Integrated Pest Management – UC IPM.* Web. Nov. 2015

An effective IPM program will use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means and with the least possible hazard to people, property and the environment.

For an example of an Integrated Pest Management Conversation Activity Plan, please visit the link below:

http://www.grainmillers.com/images/pageimages/sustainabilityportal/IntegratedPestManagementPlan.pdf

Weed Control

The most commonly recognized weed control tactics within oat production include: natural characteristics of oats, herbicide applications, and mechanical controls. Control of weeds is most effective during the lag phase of growth. Once the weed has entered the phase of exponential growth, it becomes more difficult to implement proper control. A graph of weed growth phases is shown below. Typically the most difficult weeds to control are wild oats and Canadian thistle.

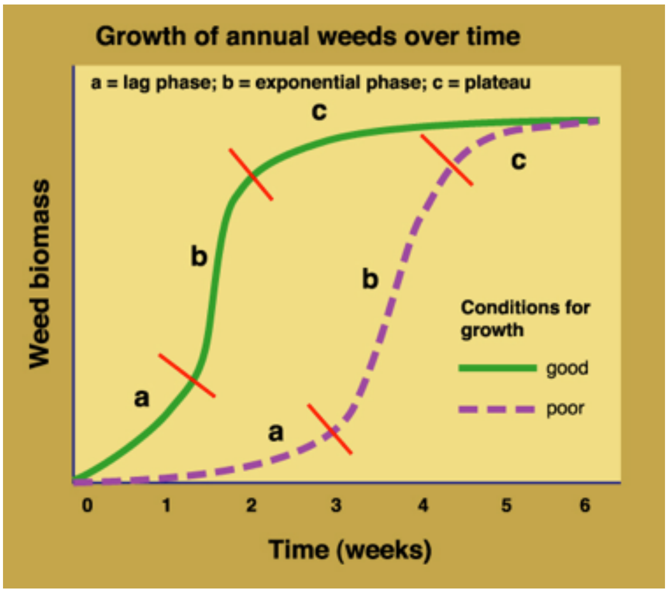


Photo from Adam Davis

Natural Characteristics

Oats have the ability to germinate in cool soils which means they can be planted early. Early planting provides many benefits to the oat crop, one of which is the germination before many weed seeds. When the crop has the ability to germinate and establish early, it will be able to provide better competition against weeds. Early growth and broad leaves will close the canopy early before the establishment of weeds.

It is reported that oats also provide an allelopathic "(the chemical inhibition of one plant acting as a germination or growth inhibitor)" [2] effect that reduces germination of many weeds. This benefit can be evident for more than just the oat season. Rye and alfalfa are also know to exhibit similar or better allelopathic effects.

[2]*Managing Cover Crops Profitably*, *3rd Ed.* 3rd ed. Sustainable Agriculture Network, 2007. 93-97. Print.

Herbicide

Conventional systems also allow for use of herbicides to help promote weed control. When using herbicide control be sure to apply at the proper time to increase effectiveness and limit crop damage. Herbicide use is best when applied in the lag phase of growth, which occurs until the weed is about two inches in size. South Dakota State University and the Government of Saskatchewan provide good information for approved herbicides. The resources are as follows:

- South Dakota Pest Management Guide for Small Grains -*see pg. 7*
- Government of Saskatchewan 2015 Guide to Crop Protection: weeds, plant disease, insects

  see pg. 45

Be sure to only use licensed and approved herbicides, and always follow label directions for application.

Mechanical control

Different types of mechanical control have been known to help with weed control. Use of a tine harrow and rotary hoe can help remove small weeds. These methods need to be used only in early growth of the oat plant. Mechanical control needs to take place before the oat plant reaches the two leaf stage. As with herbicide controls, mechanical control should be performed while weeds are just past emergence and while still in a lag phase of growth.

Dr. Steve Shirtliffe, from the Crop Development Centre of the University of Saskatchewan, has done extensive research in mechanical weed control. For additional information and techniques see Dr. Shirtliffe's research results.

Heavier seeding rates may be needed to help make up for any reduction in the stand from tillage control.

Managing Cover Crops Profitably, 3rd Ed. 3rd ed. Sustainable Agriculture Network, 2007. 93-97. Print

Plant Disease

Monitoring disease pressure is just as important in oats as any other crop. A handful of diseases bring about the largest share for concern. Crown and stem rusts, Septoria, and Fusarium Head Blight are the most prominent *fungal diseases*. These can all be treated with timely applications of fungicides in a conventional cropping system. In an organic system, control comes from genetic resistance which increases the importance of variety selection and early planting. Barley yellow dwarf or Red leaf is a prominent *virus* that can affect oats. The best management plan for this disease is genetic resistance and/or chemical control of the Cherry Oat Aphid, which is a vector for the virus.

Crown Rust

Crown rust is one of the most common and destructive diseases of oat plants in North America. This disease is caused by the fungus *Puccinia coronata f.sp. avenae*. The risk of Crown rust, like most fungal diseases can increase greatly with warm and humid weather with ample moisture. Moderate to severe epidemics can reduce grain yield by 10 to 40% (USDA ARS Crown Rust). Damage can increase as the disease moves up the plant to the flag leaf. Infection of the flag leaf greatly reduces the photosynthetic activity of the plant. This is known to reduce the number of kernels, their size and test weight. Fields should be scouted during the late 4-leaf stage and into flag-leaf.

Symptoms

The fungal disease can be seen on the top and bottom of infected leaves (Fig. x1). An infection will form a yellow-orange colored pustule. As the infection continues they will begin to turn black as the teliospores are formed within the pustule (Fig x2). The pustules can be found on any leaf of the plant and can move to the leaf sheaf during heavy infections.

Fig. x1. Early symptoms of crown rust on oats lower leaves.

Fig. x2. Infected flag leaf of oats with pustules (orange) and teliospores (black) of crown rust. Such leaf will have reduced photosynthetic activity.

Infection and Control

There are two different sources for inoculum of the crown rust pathogen. These two are the Puccinia Pathway and overwintering on the buckthorn plant. The Puccinia Pathway is the name given to the windborne movement of spores from the southern parts of the United States where it can overwinter and survive. The pathogen is also known to overwinter on the buckthorn bush (Fig.x3). It is then allowed to reproduce and infect oat plants during the optimal conditions of summer.

Despite the fact that the pathogen is constantly changing, the best initial control for this disease is through genetic resistance (Fig. x4). New oat varieties are always being bred to resist this pathogen, so be sure to select a variety that has been known to exhibit this resistance.

"Oat Crown Rust." *Cereal Rusts.* USDA ARS. Web.

"Crown Rust of Oat." *Disease.* Government of Saskatchewan, 2009. Web.

Fig. x3. Crown rust buckthorn bush. Spores blown from this shrub infect oats.

Fig. x4. Crown-rust susceptible oats cultivar (left) and moderately resistant cultivar (right)

Stem Rust

Outbreaks of this disease have not been common for about 20 years but are, once again, being reported. It is caused by the fungus *Puccinia graminis f. sp. Aveanae*. As a fungal disease, the risk of infection is impacted by the weather but the most important factor is having a virulent pathogen present.

Symptoms

Stem rust looks similar to Crown rust but there are two major differences. The first of these is the color of the pustules. Stem rust has a darker red shade, as described by the Prairie Oat Growers Association of Canada, a "brick red color." The next is the location. Crown rust does not usually show symptoms on the stem of the plant. Stem rust will be strictly on the stem with longer darker pustules (Fig. x5).

Ziesman, Barbara, Carly Huvenaars, Joseph Back, Kim Kuneff, Krista Kotylak, and Liz Simpson. *Prairie Oat Growers Manual*. 2010. Print.

Control

The most economical control for stem rust is the use of genetic resistance. Most oat varieties currently available have good genetic resistance. Fungicides can also be used for additional control. (Fungicide use will be discussed late in this section)

Fig.x5. (left) Stem rust on oats, (right) a close-up of stem rust pustules on oats

Fusarium Head Blight (FHB)

This fungal disease is known to produce the mycotoxin deoxynivalenol (DON), more commonly known as vomitoxin. It is usually present in the soil and crop residues of other cereal grains and corn. This disease can have negative effects on food quality through the production of vomitoxin. The presence of vomitoxin at levels greater than 1 ppm make consumption unsafe for humans.

Symptoms

FHB usually exhibits symptoms on the oat panicle. There will be a pink and tan shading at the base of an infected glume. The infected glume will eventually turn a tan to white color as the disease progresses.

Fig. x6. An oats spikelet infected with Fusarium Head Blight (Picture by Andy Tekauz)

Mitchell Fetch, Jennifer. “Fusarium Head Blight of Oat.” Agriculture and Agri-Food Canada. Web.

Control

Fungicide applications have been known to reduce and help control the presence of FHB in oats. When using a fungicide, be certain to use only licensed and approved formulas. Timing of the application is critical. Not rotating oats back to back with other cereal grains and corn will help reduce the prevalence of the disease.

Septoria

Septoria, also known as leaf blotch is the last of the major fungal diseases. Conditions that are conducive for infection and growth of the disease are warm and humid conditions. Constant moisture in the lower canopy is going to enhance the presence and severity of the disease.

Symptoms

Septoria is a fungal disease that exhibits symptoms first as small spots on the lower leaves of seedlings. Spots grow into larger, lens-shaped lesions which are initially yellow and later turn reddish brown.[2] Lesions are first found on lower leaves within the plant canopy.

Fig. x7. Leaves infected by Septoria Leaf blotch (Picture from AAFC and Andy Tekauz)

Control

Septoria can be controlled by early application of an approved fungicide, the economic threshold is 25% of the leaves having one or more lesions (Manitoba Ag). Avoid back-to-back cereal crops and incorporate straw to help reduce the potential of infection.

"Septoria Leaf and Glume Blotch in Wheat, Barley, and Oats. "*Agriculture, Food, and Rural Development.* Government of Manitoba, Web.

Barley Yellow Dwarf Virus

Barley yellow dwarf (BYDV) also known as “red leaf” is a prominent virus that can affect oats. This virus is usually vectored by the Cherry Oat Aphid. Plants are usually infected early in the season when aphid populations are highest. Damp and dense canopies can aid in the survival of the aphids, enhancing the potential of an infection

Symptoms

An infected leaf of a plant will start to change color and start to yellow and usually become red and necrotic. The leaf will become upright or stiff. Infected leaves margins will roll inward on themselves. Examples of oats infected with BYDV can be observed in Fig x7. and x8.

Control

A management plan for this disease consists of genetic resistance and/or chemical control of the Cherry Oat Aphid, which is a vector for the disease.

Fig x8. Oat plants infected with BYDV

Fig x9. Oat leaf infected with BYDV (From Oklahoma State University Digital Diagnostics)

Chemical Disease Control

Grain Millers recommends weekly scouting of an oat crop. IF a grower determines the need and elects to apply a fungicide, they should do so at or before flag leaf stage. Trade names of some of the most commonly used fungicide are Stratego, Headline, or Tilt. SDSU Pathologist, Emmanuel Byamukama recommends the use of Tilt fungicide (triazole fungicide) for Fusarium head blight management.

All three of the compounds listed above are approved and have residue tolerances in the US and Canada. Stratego is a mix of 2 modes of action, and tends to be a bit longer-lasting. Under stress conditions, Headline has been known to burn the crop or set it back. Tilt is an older compound (propiconazole) and has a shorter active period, but is available in several strengths and trade names, including generics.

It is important that producers recognize that none of these compounds are preventatives. Fungicides attack and kill the fungi that form the pustules. In the case of fungal diseases like fusarium, they can slow or eliminate the formation of DON and other mycotoxins. This is only exhibited at certain stages of the plant growth and the fungal growth. Many fungicides may also delay the maturity of the plant – 3 to 5 days normally. This is not normally a problem in the US, but can create issues in later planted crops or in some areas of Canada.

Scout the field for the first few pustules of rust, or for symptoms of Septoria or other fungal diseases. Warm, humid conditions with lots of dew in late mornings are ideal for most of the fungal disease formation. Spraying too late after the disease has fully attacked the plant will not yield a positive economic response. Fungicides only work if applied at the onset of the diseases.

Insects

Bird Cherry-oat Aphid

This is known to be the most common aphid found within cereal grains. In large populations it can be destructive and is the most prominent vector of BYDV.

Bird Cherry-oat aphid body color can range from orange green to olive green to dark olive green, and can occasionally have a black tinge. They have long antennae and the tube-shaped cornicles on the top rear portion of the abdomen. Usually, there is dark brown/orange patch visible spanning the cornicles.

Management of this aphid should take place once the population reaches the economic threshold. This threshold is between 50-60 insects per tiller. Scouting should take place in multiple areas of the field using a zig-zag format. The Government of Saskatchewan provides a nice guide to treatment of insect in the document listed below.

- Government of Saskatchewan 2015 Guide to Crop Protection: weeds, plant disease, insects

- See pg. 498-501

Be sure to only use licensed and approved insecticides and to always follow label directions for application.

"Bird Cherry-oat Aphid." UC Pest Management Guidelines. University of California IPM Program. Web. 8 Dec. 2015.

"Bird Cherry-oat Aphid." Wheat Insects. Kansas State University: Department of Entomology. Web. 8 Dec. 2015.

(UC Pest Management Guidelines) The picture above shows aphids on the glume of a plant, it also serves as a visual example to the appearance of the pest.

Photo Courtesy of Art McElroy and PhytoGene Resources Inc.

Insects in stored grain

Please consult attachments III and IV for information on insects in stored grain.

Maturity

Maturity

The oat head or flowering portion of the plant is somewhat different than that of other cereal crops. First, is that it is a panicle type inflorescence. Secondly, the oat panicle inflorescence matures and dries first at the top, and then moves downwards. Under normal growing conditions, approximately 90% of the grain resides in the bottom two-thirds of the head. This makes the maturity of the lower kernels extremely important to monitor. As the head starts to mature the top kernels will turn a bright white/tan color. At this point the lower kernels will still be green and the groats will not be mature. The crop is fully mature when the greenest kernels have just changed to a cream color. The oats will be around 25-30% moisture at this point.

Proper maturity at harvest is going to provide benefits in different areas concerning grain quality. Higher test weight will be observed as the plant has had time to completely fill the primary and secondary kernels. The amount of thins (kernels that fall through a 5/64" x ¾" slotted sieve) will usually decrease for the same reasons as they increase in test weight. Test weight and percentage thins usually have a strong inverse correlation in that higher thin counts will exhibit a lower test weight and vice versa.

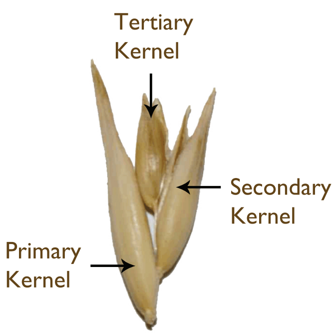


Photo Courtesy of Art McElroy and PhytoGene Resources Inc.

Pre-Harvest Glyphosate- As of April 2015, Grain Millers, Inc. will seek to purchase and encourage the production of oats where glyphosate is not used in pre-harvest applications. This is done with the intent to buy 100% glyphosate free oats when the grain delivery infrastructure can supply enough identity preserved oats.

This position on the use of glyphosate as a desiccant is driven by functional performance attributes of finished products manufactured from oats known to have been treated with glyphosate and by customer demand. This policy in no way suggests any health or food safety concerns as reviewed and regulated by both the US FDA and/or CFIA Health Canada.

Harvest

After oats have properly matured, they need to be harvested in an efficient manner. As the crop dries, kernel shattering will become a bigger issue. Efficient harvest will help protect yields and test weights. The two most popular harvesting methods are swathing the oats, then using a pickup head, and straight/direct cutting the oats. Harvest method decisions should be based on the operation and farm, and prevailing weather conditions, as one is not necessarily better than the other.

Avoid de-hulled kernels when harvesting. If conditions are very dry, widen concave and slow cylinder speeds to prevent de-hulling and kernel breakage. Perform reverse of the adjustments if threshing quality is poor. When adjusting for better threshing quality, make small adjustments at a time, then check performance. Repeat until threshing at desired quality. Increasing fan speed has been known to provide heavier test weights and higher milling quality oats.

Swathing
When looking to swath oats, grain moisture and maturity level is not as crucial. Swathing provides a window as the grain can dry and finish final development within the swath. Swathing is also encouraged in situations of high levels of weeds present, as it allows the weeds to also dry down and not become part of the harvested grain. While drying will occur in the swath, the oats should not be cut until they are below the 35% moisture mark. The optimal point is in the 20 – 25%. If grain bin aeration is available the oats should be picked up at approximately 14%. If no aeration is available wait till the oats are around the 13% to prevent problems with high moisture. It is important to remember Grain Millers purchasing specification on oat moisture is 13.5%.

Swathing can help with harvest if maturity is uneven across the field. By swathing down the oats they will dry and can be harvested at a more consistent grain moisture. Another benefit is if the field has a fair amount of weeds swathing will help them dry and ease harvest. The biggest risk of having oats in a swath is rain. Excess rain on a swath will decrease quality and food grade potential. Damage and discoloration of the hull is not as big a concern as groat condition and color. Sprouting will be one of the most noticeable quality reductions, along with groat staining and discoloration. If darkened or stained kernels appear in the grain stream, we recommend dehulling several of the kernels to observe the groat condition, looking for staining, darkening, and/or sprouted groats.

Straight Cutting
Oats need to be fully mature and dried before straight cutting. The best time to straight cut oats is a grain moisture of approximately 14 – 15%. Harvest should only be done at this point if aeration is available immediately to bring the moisture content of the grain down to a safe storage level. If no aeration is available, it would be best to wait for a grain moisture of about 13%. It is important to remember Grain Millers specification on oat moisture is 13.5%.

This method also prevents the necessity of having the crop on the ground and in a heavy swath, subject to wet weather and soil conditions. Straight cutting works best if maturity in the field is even. Try to avoid cutting green spots in the field until those areas are fully mature; this will help reduce the amount of green kernels in the grain. Make sure to consult the specifications on green kernel allowance. The primary risks with doing a direct cut are the kernel shatter that may occur during harvest, straw breakage, and lodging.

Safe Storage Recommendations

All farmers strive for quality grain production, which includes the correct variety, high quality seed, clean fields, balanced fertility programs, effective weed and insect control, and safe and clean harvest. But the quality story certainly doesn't end there. With the trend toward increased on-farm storage, additional opportunities, risks, and responsibilities are assumed by the farmer with larger size bins and volumes stored on-farm**.** **Remember** – the oats delivered to Grain Millers is intended for human FOOD. Listed below are the recommendations for the safe and effective storage of oats on-farm, in order to preserve grade, prevent damage from molds and insects, and ensure food safety of the quality oats harvested is maintained.

1. All bins and handling equipment – regardless of size/capacity, frequency of use, and location MUST be thoroughly cleaned, removing all previous grain residues, molds, and debris. This includes cleaning out of all bin augers and transfer equipment, as well as under perforated drying and/or aeration floors. Molds, insects, grain dust, foreign material, broken grain, and water collect in these areas, and can quickly create a "cocktail" of molds and mycotoxins which can then be spread effectively into the stored grain mass.

   SAFETY FIRST – always disconnect all power sources to any mechanical devices and/or bins before cleaning.

2. All bins, regardless of size or structure, must be completely sealable to prevent water from getting to the grain (rain, snow, wind, etc.) and insect infestation. All bins should have tight hatches and covered vent openings, and all bin sites should provide a clean area around the bins with no weeds, piles of debris, and old grain spillage, in order to avoid insect and mold growth. Repair any hole, crack, or seam with a food safe, strong material prior to filling the bin.

3. All oats must be uniformly dried and cooled to ambient temperatures prior to long term (over 1 month) storage. Although some "equilibration" of moisture can occur in grain masses, you should NEVER blend wet oats (over 13%) with dry grain, and simply hope for moistures to "even out". Insects will seek out the damper grain pockets, and molds and mycotoxins will grow quickly in ambient air. Immediately after drying grain, attempt to cool it to within 10 degrees F of outside air.

4. Never dry oats over approximately 110 degrees F (actual grain temperature), and use high volumes of air. The hull on the oats kernel can be an effective "shield", complicating air flow, and depending upon the starting grain moisture, the oats kernel may not dry as quickly or uniformly as other grains. High heat not only can damage the groats, it can be a potential fire hazard, as the hull will dry faster than the groat.

5. We recommend long term uniform storage moistures of clean oats grain to be 11% to 13%.

6. If the harvested oats contains significant levels of foreign material, we highly recommend cleaning the grain with a mechanical grain cleaner/sieve and/or air volume prior to storage. Foreign material (fines, weed seeds, dirt, etc.) is normally higher in moisture than the actual grain kernels. The oat grain stores much better with air movement throughout the bin, and some relatively easy cleaning prior to long term binning facilitates air movement through the grain.

7. Provide for adequate ventilation of the grain via aeration fans, attempting to keep the grain within 10 degrees F of ambient outside temperature. During the fall and early winter, cool the grain on a regular basis until the grain temperature nears freezing. For extended storage periods, you should warm the grain in the spring, attempting to bring the grain up 5 degrees F or less at a time to avoid moisture formation in the grain mass. It is critical that once a temperature change is initiated, it must be continued until complete. If this is not done, when the aeration is stopped, the warm, moist air will condense on the cool grain, and a crust will develop, usually within the top few feet of the grain mass. . During summer months, aerate during cool, dry nights to hold grain temperatures down. Depending upon bin size, volume of grain stored in that bin, and bin manufacturers, a general rule of thumb for effective grain aeration is at least 1/4th CFM/bu.

8. Licensed grain fumigants can be used for non-organic certified oats stored for several months on-farm, but must not leave ANY traces of residues. Malathion is considered a grain protectant and should be applied to bin surfaces. The University of Minnesota recommends the following: “Apply these residual insecticides to as many surfaces as possible, especially joints, seams, cracks, ledges, and corners. Spray the ceilings, walls, and floors to the point of runoff.” It must be applied before grain storage and have dried before grain contact. Diatomaceous earth application is approved, but farmers must notify Grain Millers of its use prior to delivery.

9. Develop a plan and schedule for safe grain moisture and temperature monitoring. During the fall and spring, we recommend checking the bins weekly to avoid rapid moisture and temperature variations. Remember, on warm spring days, the grain just inside the shiny metal walls on the sunny side of the bin warms quickly, while doing so far more slowly on the shaded side. The bin can then form its own “atmosphere”, and grain spoilage can occur.

10. If aeration is not option for a bin, many farmers have successfully “turned” (emptying and refilling) a bin while incorporating a rapid, effective cleaning operation to remove more fines, debris, and light material. Many farmers have actually reported small increases in test weights when performing this operation, and being able to store the grain longer. Effective, licensed fumigations can also be performed along with this practice.

“Preventing Stored-grain Insect Infestation.” *Small Grains Production.* University of Minnesota Extension. Web. Dec. 2015.

Food Applications of Oats

The popular question of “what do you guys do with all these oats,” comes up a lot. As a company Grain Millers focuses on one thing and that is milling for food consumption. Oats can be milled into a variety of different products. These products go into different food items that are consumed on a regular basis. Three of the more common items produced are regular rolled oats, steel cut oats, and flour. Each of these has a slightly different purpose.

Oats are made up of two parts. The first and outer part is the hull, its purpose is to protect the groat from damage. Hull content is usually around 30 percent of the total weight. The second, and most important, part is the oat groat. This is the portion that is milled and put into a variety of different products.

Regular rolled oats are the larger flakes that most people think of when discussing milled oats. These are the ingredients that go into things such as hot cereals, such as oatmeal, and granola. The granola can either be made into bars or packaged.

Steel Cut oats are a product that that goes through a sizing and cutting process to create small pieces of oat groats. These pieces are than flaked to create the smaller oat flakes seen is some products. These flake are prominently used in instant oat meal.

Oat flour is a widely used item produced from oats. The best known application for oat flour is the used in puffed cereal. It is also used in applications such as baby food.

Appendix 1

U.S. Recommended Variteties for Milling Oats

Variety	Breeding Origin	Maturity	Crown Rust	Stem Rust	BYDV	Hull Color
Preferred - Southern/Eastern Midwest						
Badger	U of Wisconsin	Early	S	S	MR	Yellow
Sabers	U of Illinois	Early	MR	S	R	Yellow
Spurs	U of Illinois	Early	MR	S	R	Tan
Deon	U of MN	Late	MS	MS	MR	Yellow
Preferred - Northern/Western Midwest						
Shelby 427	SDSU	Medium	S	MR	R	White
Hayden	SDSU	Late	MS	MS	MR	White
Newburg	NDSU	Late	S	R	MS	White
Rockford	NDSU	Late	S	MR	R	White
Acceptable						
Colt	SDSU	Early	MS	S	MS	White
Excel	Ag Alumni Seed	Early	S	S	R	Yellow
Tack	U of Illinois	Early	R	S	R	Tan
Beta-Gene	U of Wisconsin	Medium	MR	MR	R	Yellow
Horsepower	SDSU	Medium	S	S	MR	White
Souris	NDSU	Late	S	MS	MS	White

R - Resistant
MR - Moderately Resistant
MS - Moderately Susceptible
S - Susceptible

Grain Millers recommends the frequent scouting of oats fields for both insects and plant diseases from early in the growing season through heading. If leaf fungal diseases are seen, the timely application of registered and approved fungicides for non-organically grown oats is approved and recommended to enhance both yield and grain quality potential. Contact Grain Millers for more information.

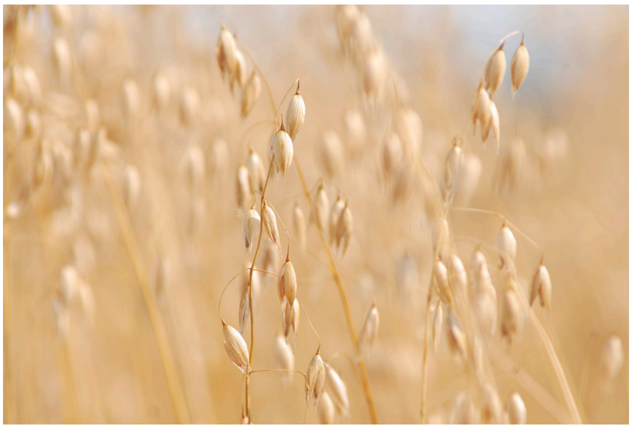
At the time of publication, it is believed that the varieties listed above, combined with good agronomic characteristics and management, should provide the best opportunity for growers to produce food quality oats. Before purchasing or planting oat varieties not listed, please contact Grain Millers to discuss attributes of other varieties considered.

Descriptions of U.S. Recommended Varieties

Early Season

Badger — Badger is an early season, yellow hulled oat developed at the University of Wisconsin. It has the same heading date as Dane and is two days earlier than Kame. Badger has had consistently high grain yields and excellent test weight compared to other early season oat. Lodging percentage is fair to good and about equal to Vista. Badger is one inch shorter than Kame. Badger has some barley yellow dwarf virus tolerance and is susceptible to crown rust.

Colt — A white hulled oat developed at South Dakota State University and when compared to the older University of Illinois variety 'Don,' has superior grain yield, test weight, protein percentage, and groat percentage. The disease ratings include: resistance to smut, susceptible to crown rust, and moderately susceptible to BYDV. Colt also has a short-to-medium plant height and a very early maturity. It is a multi-purpose variety that may be used for companion crop, multi-cropping, and/or harvesting for grain.



Excel — Medium early maturity, high yielding, medium height and strong straw strength. Ivory yellow seed, with good test weight and groat percentage. Excel is moderately susceptible to crown rust and loose smut. It has good tolerance to yellow dwarf viruses and is susceptible to stem rust. Selected at Purdue Agricultural Experiment Station and released in 2007.

Saber — The pedigree of Saber is 'Tack'/'Spurs'. Tack and Spurs are both spring oat cultivars developed and released by the University of Illinois Agricultural Experiment Station. Saber is a yellow hulled oat selected and released based on its combination of excellent yield, high test weight, and tolerance to *Barley yellow dwarf virus* when compared to other early oats.

Spurs — An oat variety released by the Illinois Agricultural Experiment Station. This variety has high yield potential combined with good test weight and tan to white kernel color. Spurs is moderately early and has moderately short plant type. The barley yellow dwarf virus tolerance and crown rust resistance of Spurs is similar to Blaze.

Tack — A spring oat variety adapted to the Midwestern U.S. and released by the Ill. Ag. Exp. Station. It is a tan-seeded variety very good yield potential with exceptionally high test weight for an early season oat. It exhibits good barley yellow dwarf virus tolerance and has reduced crown rust resistance. Lodging resistance is similar to Ogle.

Medium Season

Beta Gene — Beta-Gene is a high yielding oat developed by the University of Wisconsin. It has good straw strength and a stature that is similar to the variety Drumlin. In research plots Beta-Gene has displayed good test weight. It shows resistance to Crown Rust and Barley Yellow Dwarf Virus.

Horsepower — Horsepower oats is a white-hulled spring grain oat, developed by the South Dakota Agricultural Experiment Station. Horsepower has high yield potential and strong straw strength. It is early-medium maturity with short plant height and an average test weight. It is susceptible to crown rust, resistant to Barley Yellow Dwarf Virus (BYDV), and moderately susceptible to stem rust and smut.

Shelby 427 — Shelby427 has a high yield potential, test weight, and groat percentage developed at South Dakota State University. The disease ratings include resistance to smut and BYDV, moderate resistance to stem rust, and susceptibility to crown rust. Shelby427 also has excellent lodging resistance, a medium plant height, and an early maturity. It is a multi-purpose variety that may be used for feed grain, milling oat, companion crop, forage, and/or straw production.

Late Season

Deon — A high yielding spring yellow oat with overall good agronomic traits from the University of Minnesota. It has good test weight and is medium yellow in color. Maturity rating, height and lodging score is similar to North Dakota varieties but Deon has a better resistance to barley yellow dwarf virus. It also has moderately susceptible to crown rust resistance and has resistance to smut.

Hayden — Is a mid to late maturing line with excellent yield potential and high test weight. It is a white-ulled oat line from South Dakota State University. Maturity and lodging are similar to Newburg with a height that is on average a few inches shorter. It is resistant to smut, moderately resistant to BYDV, moderately susceptible to crown and stem rust.

Newburg— A high yielding oat variety adapted to the North Central states and to the prairie provinces of Canada. Newburg is most similar to HiFi but is resistant to stem rust. Kernels of Newburg are white, fluorescent, medium to large, and mid-plump. It is susceptible to crown rust, contains moderate resistance to Barley Yellow Dwarf Virus (BYDV), and is moderately susceptible to stem rust.

Rockford — A high yielding variety that offers very good lodging resistance. It is a white-hulled spring grain oat, developed by North Dakota State University. Rockford is susceptible to crown rust, moderately susceptible to stem rust race NA67, and is tolerant to barley yellow dwarf virus.

Souris — Medium-tall, medium maturity oat from North Dakota State University. High yielding, white-hulled cultivar with test weights consistently high enough for premium oat markets. Souris will grow under high moisture and fertility conditions. It has good tolerance to yellow dwarf viruses and is susceptible to stem and crown rust.

RECOMMENDED VARIETIES FOR MILLING OATS
Eastern Canadian Provinces

Recommended

- AC Dieter
- AC Aylmer
- CDC Orrin
- CDC Dancer
- AC Nicolas
- Nice

Acceptable

- Triactor
- Vitality

Non-Preferred

- Bia
- Vitality
- Canmore
- Optimum
- Avata
- Almonte
- Richmond
- Bolina
- Nova
- Rigodon

RECOMMENDED VARIETIES FOR MILLING OATS
Canadian Prairie Provinces

Recommended:		**Acceptable:**	
-Camden [1]	-Minstrel	-Morgan [1,2]	-Betania
-Summit	-Souris	-Dancer	-Orrin
-Leggett	-Stride	-Triactor [1]	-Pinnacle
		-Seabiscuit	

Prohibited Varieties:

-Gwen	-Mustang	-Whitestone	-Jasper
-Jordan	-Grizzly	-Juniper	-Feed Varieties
-Lu	-Bullion	-Boudrias	-Hullless Varieties
-Ronald	-Cascade	-Murphy	-Forage Style Varieties

Varieties Under Review:

-Oravena	-Justice	-OT6008
-Ruffian	-Norseman	-OT6009

[1] Due to reduced rust resistance this variety may require a fungicide application, under conventional systems, in rust prone areas

[2] Preferred Variety in Northern Alberta

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At the time of publication, it is believed that the varieties listed above, combined with good agronomic characteristics and management, should provide the best opportunity for growers to produce food quality oats. Before purchasing or planting oat varieties not listed, please contact Grain Millers to discuss attributes of other varieties considered.

Appendix II

Official Grain Millers, Inc. Oat Purchasing Specification Grading Factors

Quality Standards

	Target	Min/Max	Spec
Test Weight	40	36	38
Moisture	13%	10-14%	13.5%
Thins	5%	20%	12%
De- Hulled	6%	12%	8%

Foreign Material

	Target	Min/Max	Spec
FM (Conv)	1%	3%	2%
FM (Org)	2%	5%	3%
Legumes	0%	1%	0.5%
Oil Seeds (Canola)	0%	1%	0.5%
Barley	0%	2%	1%
Wheat	0%	2%	1%
Total Other	0%	2%	2%
Wild Oats	0%	2.5%	2%
Ergot	0%	0.02%	0.02%

Damage

	Target	Min/Max	Spec
Frost	0%	2%	0%
Sprout	0%	2%	0%
Green	0%	1%	0%
Total of Above	0%	3.0%	2%
Fusarium	0%	1.0 ppm	0.1ppm
Heated	0%	0.1%	0.1%

Test Weight Conversions

Lb/W.bu	*g/0.5 L*	*Lb/W.bu*	*g/0.5 L*
34.0	219	**39.0**	251
34.5	222	**39.6**	255
35.1	226	**40.0**	258
35.5	229	**40.5**	261
36.0	232	**41.0**	264
36.5	235	**41.6**	268
37.1	239	**42.1**	271
37.6	242	**42.5**	274
38.0	245	**43.0**	277
38.5	248	**43.5**	280

1. Discounts MAY apply to any grain delivered out of spec. See – Discount Schedule
2. FM – Thru 8/64” triangle sieve
3. Thins – Thru 5/64” x ¾” slotted sieve
4. Plump – On top of 6/64” sieve
5. Moisture Tested on Dickey John

Pest/Pesticide/Odors - Restriction

- Oats must contain NO signs of infestations (dead or alive) or insect damaged kernels delivered to ANY GMI facility
- Oats which have been treated with **glyphosate** as a pre-harvest desiccant will not be accepted due to problems in the functionality of milling.
- Oats must not contain detectable levels of pesticide, chemicals, or any other objectionable

Grain Millers, Inc. reserves the right to change these specifications at any time without prior notice

Appendix III

Principle Stored Grain Insects

GRANARY WEEVIL *Sitophilus granarius*
Length: Approximately 4 mm

Small, moderately polished, blackish or chestnut-brown beetle. The head extends into a long slender snout with a pair of stout mandibles or jaws at the end. There are no wings under the wing covers, and the thorax is well marked with longitudinal punctures, two characteristics that distinguish this insect from the closely related rice weevil with which it is often found.

The adult live an average of 7 to 8 months. Each female lays 50 to 250 eggs during this period.

After mass infestation, the grain becomes warm and damp, this leading to the formation of mold.

RICE WEEVIL *Sitophilus oryzae*
Length: Approximately 3 mm

Small snout beetle; varies from reddish brown to nearly black and is usually marked on the back with four light-reddish or yellowish spots. It has fully developed wings beneath the wing covers. The thorax is densely pitted with somewhat irregularly shaped punctures; except for a smooth narrow strip extending down the middle of the upper (dorsal) side.

The adult live an average of 4 to 5 months, and each female lays 300 to 400 eggs during this period. The early life stages are almost identical in habit and appearance to those of the granary weevil.

MAIZE WEEVIL *Sitophilus zeamais*
Length: Approximately 5 mm

A small snout beetle. It varies from dull red-brown to nearly black and is usually marked on the back with four light reddish or yellowish spots. It is slightly larger than the rice weevil and has more distinct colored spots on the forewings.

The maize weevil has fully developed wings beneath its wing covers and can fly readily. The thorax is densely pitted with somewhat irregularly shaped punctures, except for a smooth narrow strip extending down the middle of the dorsal (top) side.

While developing, the larvae eat the internal contents of the maize; approximately 18 to 23 days.

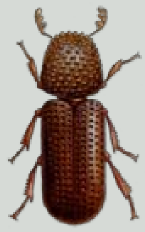
CADELLE *Tenebroides mauritanicus*
Length: Approximately 9 mm

An elongate, oblong, flattened, black or blackish beetle.

Both the larva and adult feed on grain and have the destructive habit of going from kernel to kernel devouring the germs. Found in mills, granaries, and storehouses where it infests flour, meal, and grain.

It is one of longest lived of the insects that attack stored grain. Many of the adults live for more than 1 year and some of them for nearly 2 years. Both the larvae and adults can live in the woodwork of the bin for a long time after the grain has been removed.

LESSER GRAIN BORER *Rhizopertha dominica*
Length: Approximately 3 mm



Slender, cylindrical form and small size. Polished dark brown or black, with a somewhat roughened surface. The head is turned down under the thorax and is armed with powerful jaws used for cutting into wood.

Both the beetles and larvae cause serious damage in warm climates by attacking a great variety of grains.

The eggs are deposited on the outside of the kernels. Badly infested wheat takes on a honey-like odor.

SAW-TOOTHED GRAIN BEETLE *Oryzaephilus surinamensis*
Length: Approximately 3 mm

Slender, flat, brown beetle. It gets its name from the peculiar structure of the thorax, which bears six sawtoothlike projections on each side.

It attacks in both the larval and adult stages. The adults live on an average 6 to 10 months. The female lays 43 to 285 eggs.

Infests mainly grain and grain products but also noodles, wafers, nuts, and dried fruit. Causes sometimes the so-called "hot spots" in stored grain.

FLAT GRAIN BEETLE *Cryptolestes pusillus*
Length: Approximately 2 mm

Minute, flattened, oblong, reddish-brown beetle, with elongate antennae about two-thirds as long as the body. One of the smaller beetles commonly found in stored grain.

Females deposit small white eggs in crevices in the grain or drop them loosely upon farinaceous material. The larvae are fond of the wheat germ, and, in infested grain, many kernels are found uninjured except for the removal of the germ. Larvae also feed on dead insects.

Frequently found in enormous numbers with the rice weevil. This insect is a scavenger and often infests grain and meal that are in poor condition.

CONFUSED FLOUR BEETLE *Tribolium confusum*
Length: Approximately 4 mm

Shiny, flattened, oval, reddish-brown beetle. The head and upper parts of the thorax are densely covered with minute punctures. The wing covers are ridged lengthwise and are sparsely punctured between the ridges.

The average life is about 1 year. Badly infested flour has a sharp odor and turns brown; its baking properties are damaged.

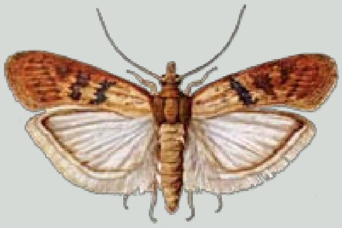
This beetle is closely related and almost identical in appearance to the Red Flour Beetle.

ANGOUMOIS GRAIN MOTH *Sitotroga cerealella*
Length: Approximately 8 mm
Wing span: Approximately 16 mm

Small buff or yellowish-brown moth. The rear edges of the forewings and hindwings have long fringes.

Larva crawl to a kernel of grain and often spins a small cocoon to assist it in boring into the hard kernel. After entering the grain, it feeds on either the endosperm or the germ until fully grown. It attacks all types of grain, particularly corn and wheat. Badly infested grain has a sickening smell and taste that makes it unpalatable.

INDIAN MEAL MOTH *Plodia interpunctella*
Length: Approximately 17 mm
Wing span: Approximately 17 mm



Easily distinguished from other grain pests with peculiar markings of its forewings which are reddish brown with a copper luster on the outer two-thirds but whitish gray on the inner or body ends.

Each female lays 100 to 300. Larvae feed upon grains, grain products, dried fruits, nuts, and a rather wide variety of foodstuffs.

Fully grown larva leave a silken thread behind wherever it crawls.

Appendix IV

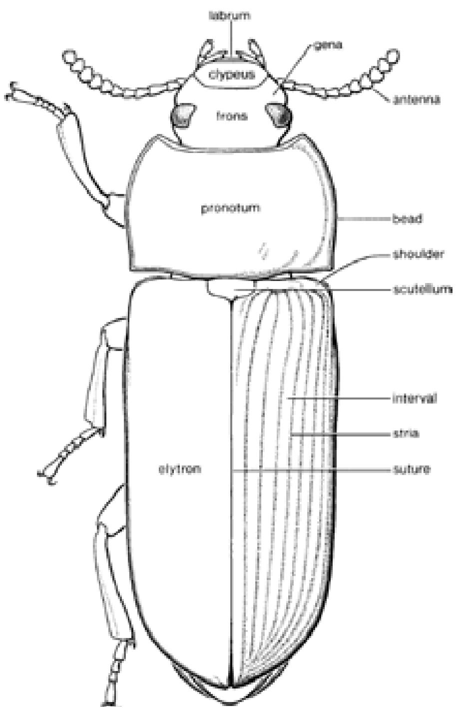
Canadian Grain Commission | Commission canadienne des grains

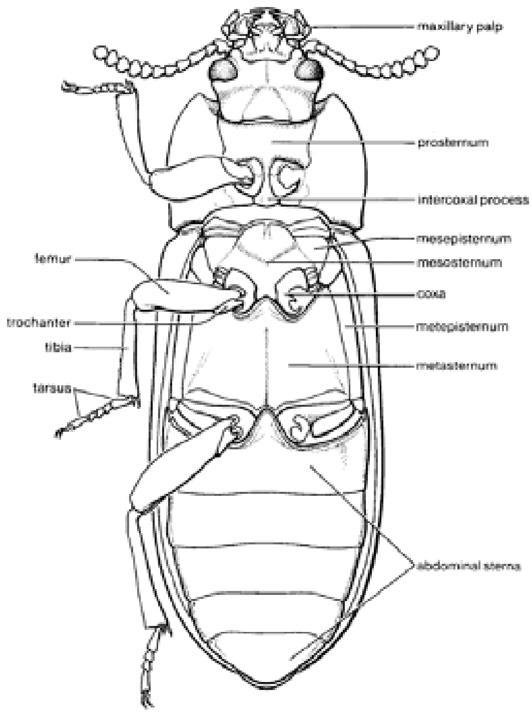
Short guide to common adult insects found in stored grain in Canada

Canada

Beetle Anatomy

(From: Bousquet, Y., 1990. Beetles associated with stored products in Canada: An identification guide.)





Simple key to common adult insects found in stored grain in Canada

Figure 1.1.

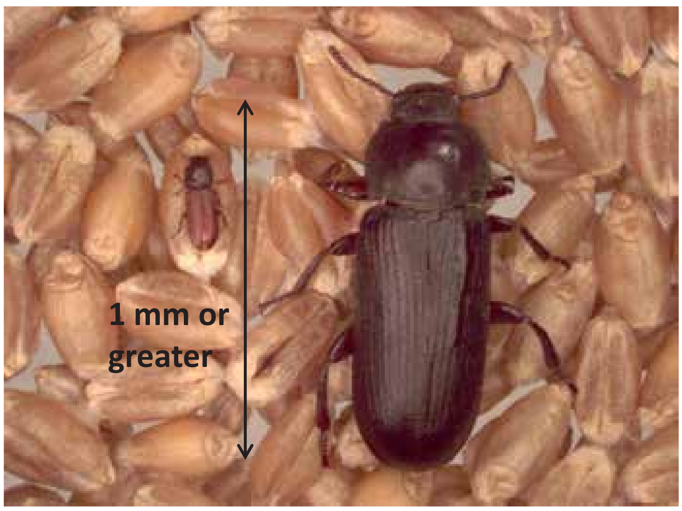


Figure 1.2.

1 **Length 1 mm or less**
Go to couplet 2

1’ **Length greater than 1 mm**
Go to couplet 3

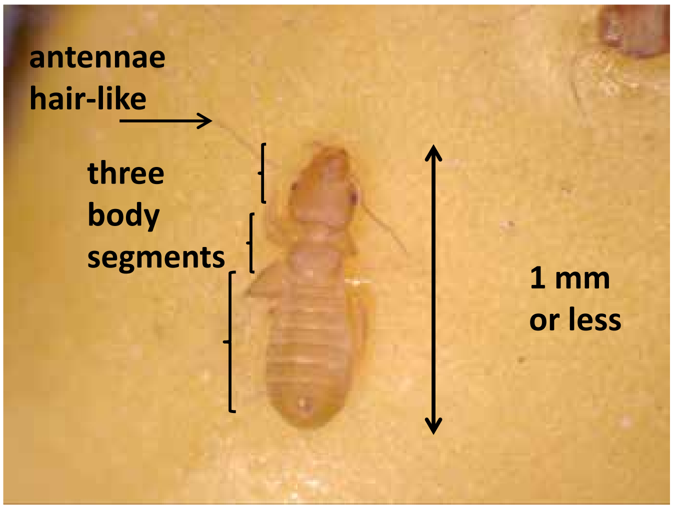


Figure 2.1.

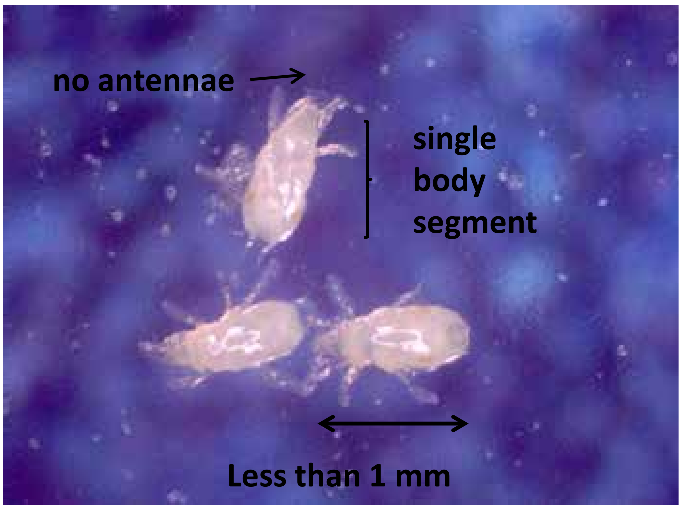


Figure 2.2.

2 Antennae long and hair-like, body clearly in three segments, six legs.

Booklice or Psocids

2’ Antennae absent, single body segment, eight legs.

Grain mites

Figure 3.1.

Figure 3.2.

3 Is it a moth?

Lepidoptera

3’ Not a moth?

Go to couplet 4

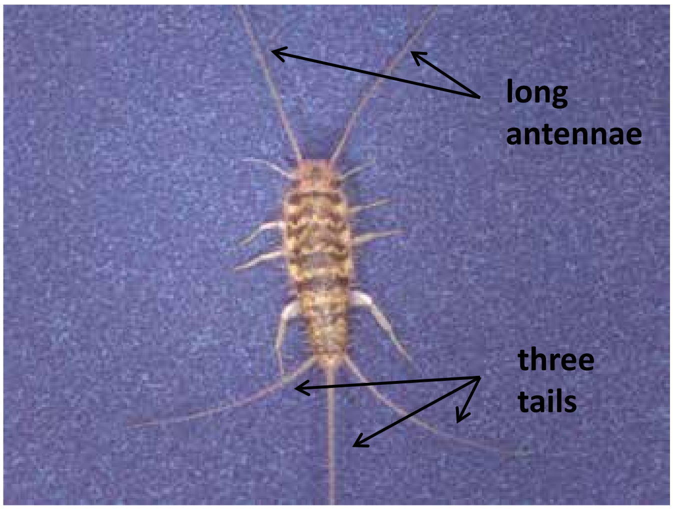


Figure 4.1.

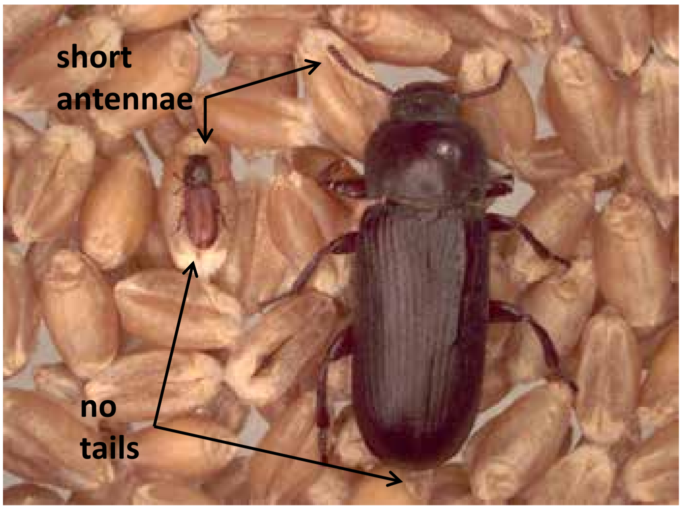


Figure 4.2.

4 Larger insect with two long antennae and three distinct tails present.

Silverfish or Firebrat

4’ May be large or small insect with antennae but no distinct tails.

Go to couplet 5

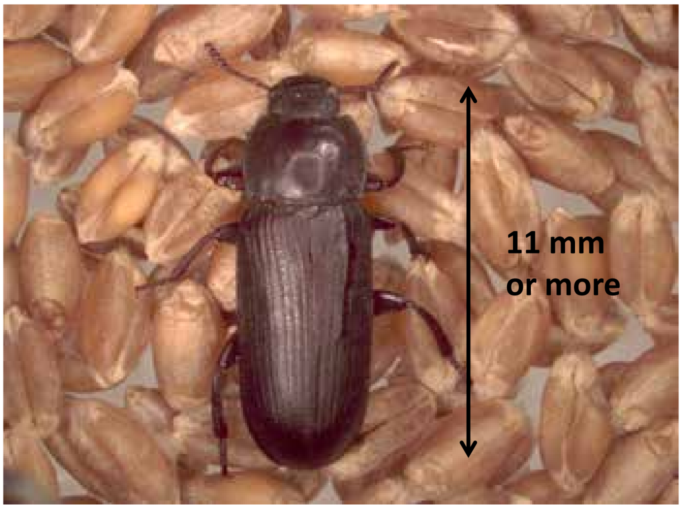


Figure 5.1.

Figure 5.2.

5 Larger insect, 11 mm or more in length.

Yellow mealworm – *Tenebrio molitor*

5’ Smaller insect, less than 1 mm in length.

Go to couplet 6

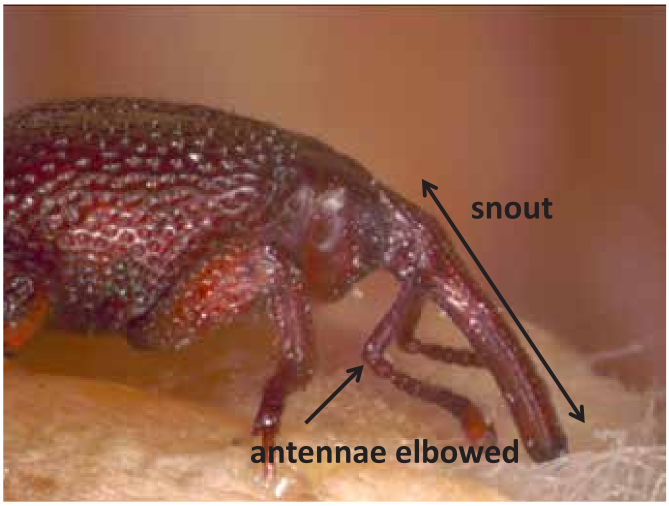


Figure 6.1.

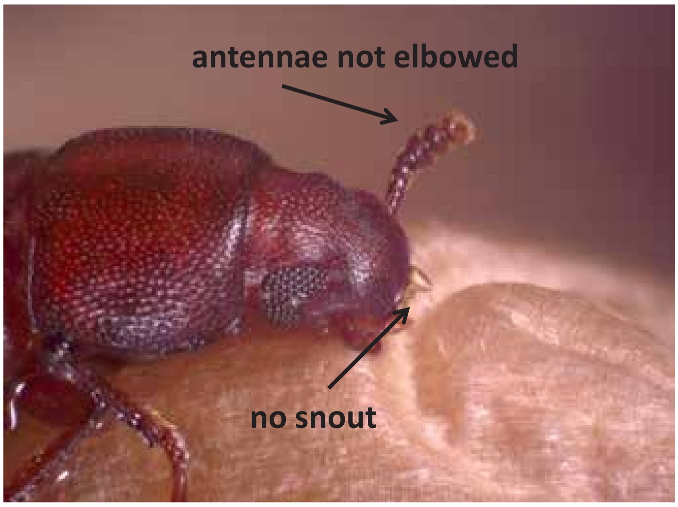


Figure 6.2.

6 Head prolonged into a snout, antennae elbowed (weevil).

Go to couplet 7

6’ Head not prolonged into a snout, antennae straight without distinct elbow.

Go to couplet 8

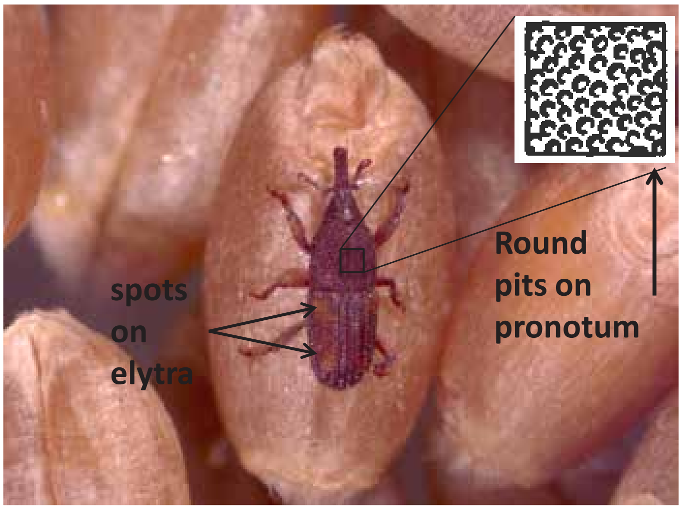


Figure 7.1.

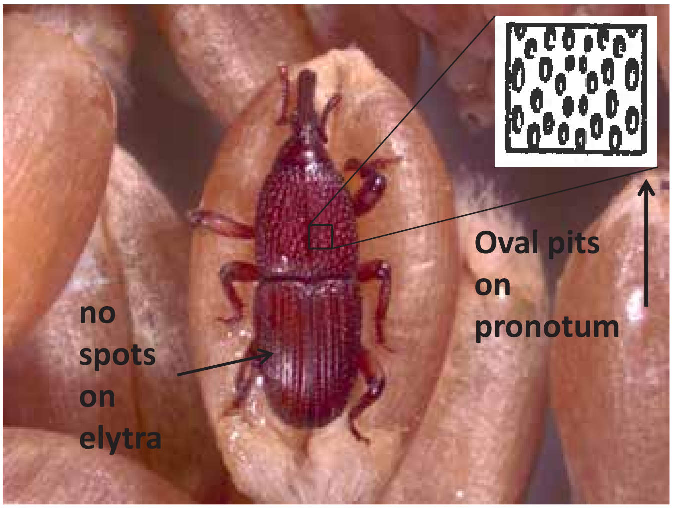


Figure 7.2.

7 Four red to brown spots on back (elytra), pits on pronotum round in shape.

Rice weevil – *Sitophilus oryzae*

(may be the maize weevil, *Sitophilus zeamais*, cannot tell apart by external features).

7’ No spots on back (elytra), uniformly dark brown, pits on pronotum oval in shape.

Granary weevil – *Sitophilus granarius*

Figure 8.1.

(other species with head not visible from above click here)

8 Head not visible or only partially visible from above.

Go to couplet 9

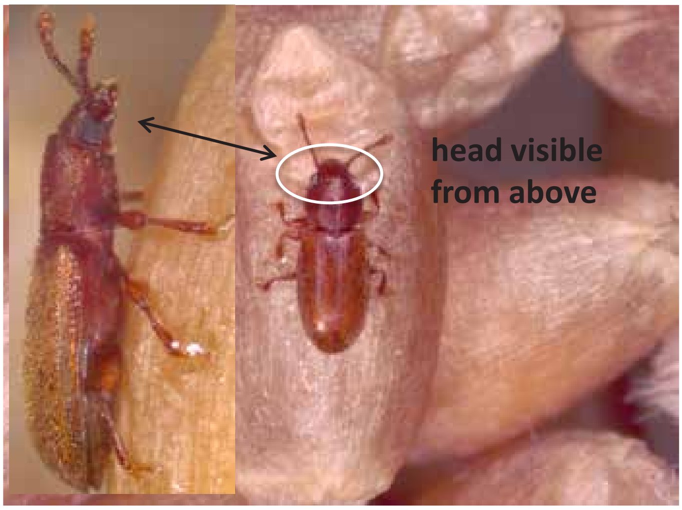


Figure 8.2

8’ Head clearly visible from above.

Go to couplet 11

Figure 8.3.
Trogoderma variabile (dermestid beetles) head not clearly visible from above.

Figure 8.4.
A spider beetle, *Ptinus fur* head not clearly visible from above.

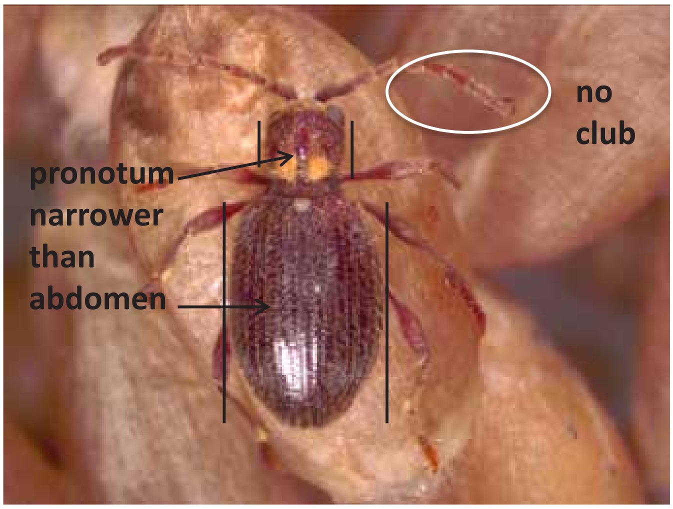


Figure 9.1.

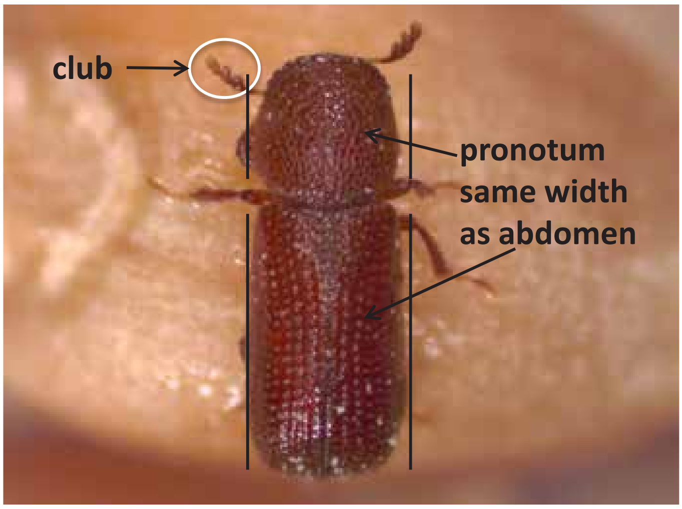


Figure 9.2.

9 Antennae long with segments uniform in shape, pronotum narrower than abdomen, abdomen and pronotum slightly rounded (not parallel sided), may be spider-like in appearance.

Spider Beetles - Ptininae

9’ Insect with antennae variable in length (usually short) but end in more or less distinct club, pronotum and abdomen same width.

Go to couplet 10

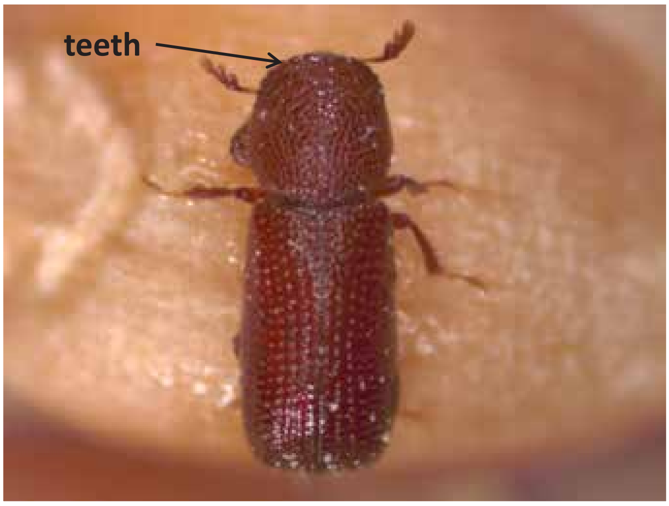


Figure 10.1.

Figure 10.2.

10 Abdomen and pronotum parallel sided, not round in shape; cylindrical in cross section; shiny and uniform in colour; pronotum with rasp-like teeth.

Lesser Grain Borer – *Rhyzopertha dominica*

10’ Round or oval in overall shape, covered with setae (hair) or scales and appearing hairy or fuzzy; colour variable and may be patterned; front edges of pronotum strongly curved.

Hide Beetles or Larder Beetles - Dermestidae

Figure 11.1.

Figure 11.2.

11 Pronotum with teeth-like projections (6).

Saw-toothed grain beetle – *Oryzaephilus surinamensis*

11’ No teeth-like projections pronotum.

Go to couplet 12

Figure 12.1.

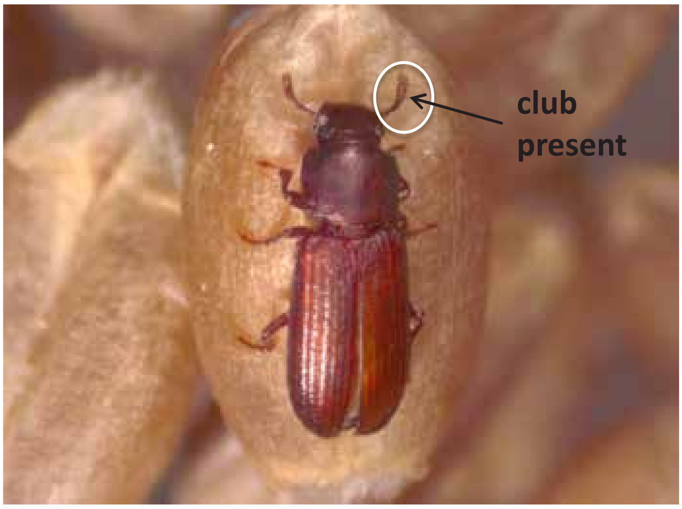


Figure 12.2.

12 Insect with antennae long with segments uniform in shape, not ending in a club.

Rusty grain beetle – *Cryptolestes* spp. Most likely to be the rusty grain beetle but difficult to distinguish between species.

12’ Insect with more or less distinct clubbed antennae.

Go to couplet 13

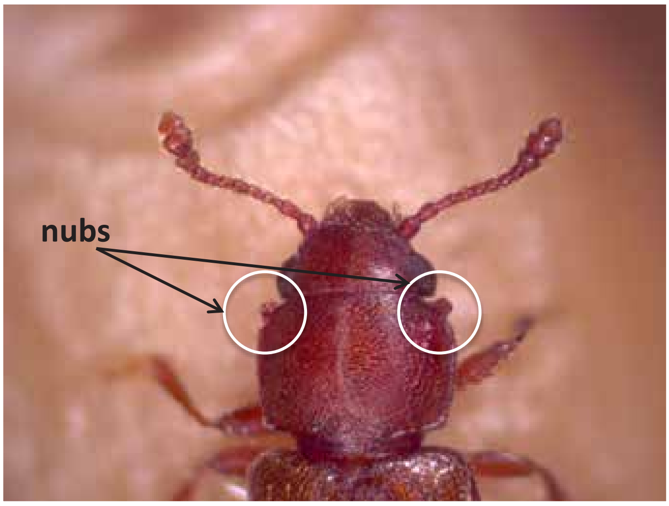


Figure 13.1.

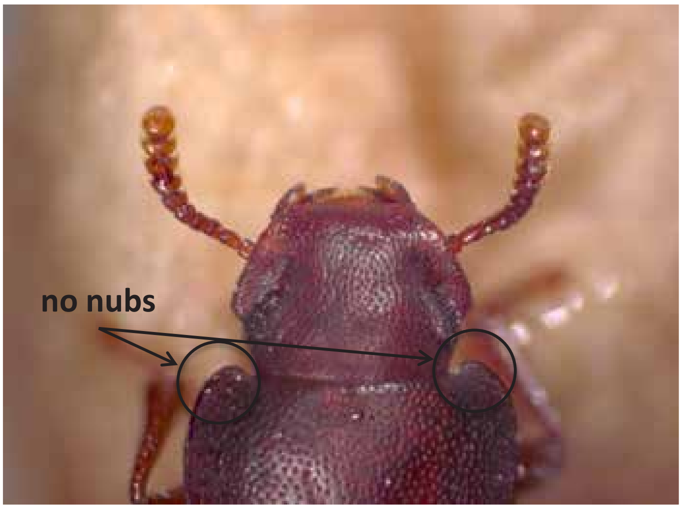


Figure 13.2.

13 Conspicuous tooth on front corners of pronotum. Antennae with distinct club. Combination often referred to as 'nubs and clubs'.

Foreign grain beetle – *Ahasverus advena*

13' No conspicuous tooth (or nub) on front corners of pronotum.

Go to couplet 14

Figure 14.1.

Figure 14.2.

14 Red flour beetle
Tribolium castaneum

14' Confused flour beetle
Tribolium confusum

Gap between eye differences:
Gap narrow or wide.
View comparison here

Antennal club differences:
Club distinctly or gradually enlarged.
View comparison here

Lateral eye width differences:
Eye more than four or only two facets wide at narrowest point.
View comparison here

Figure 14.3.

Red flour beetle
Tribolium castaneum – antennal club abruptly enlarged.

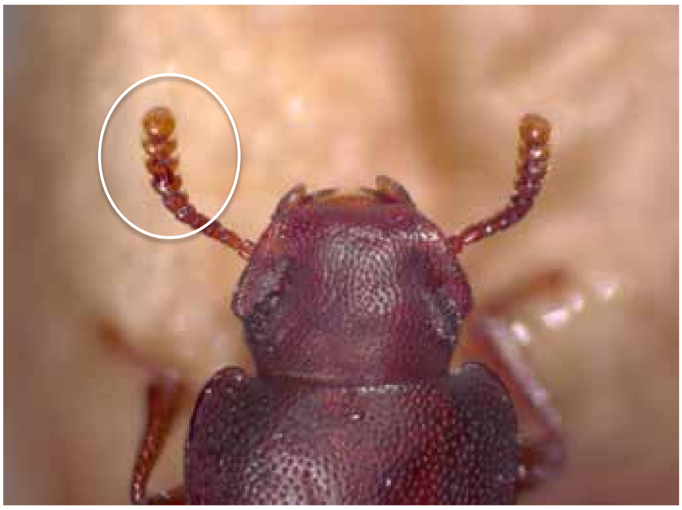


Figure 14.4.

Confused flour beetle
Tribolium confusum– antennal club gradually enlarged.

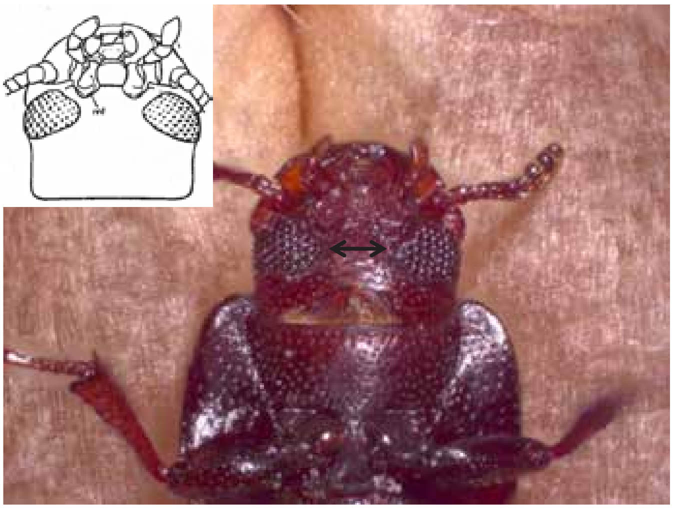


Figure 14.5.

Red flour beetle
Tribolium castaneum – gap between eyes relatively narrow (about 33% of head width).

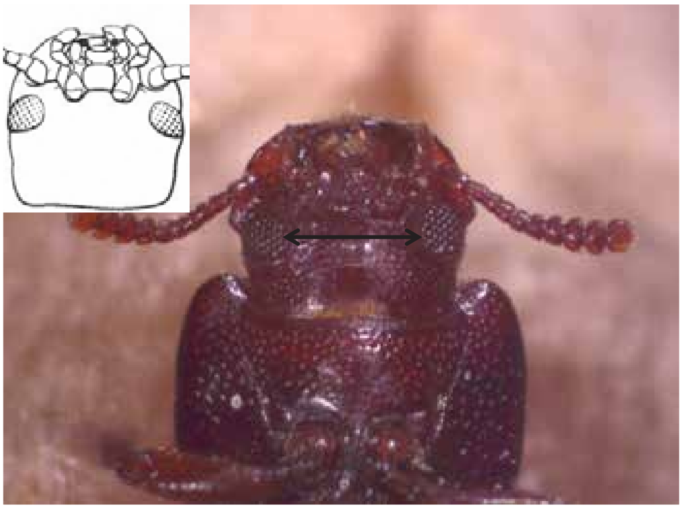


Figure 14.6.

Confused flour beetle
Tribolium confusum– gap between eyes relatively wide(about 50% of head width).

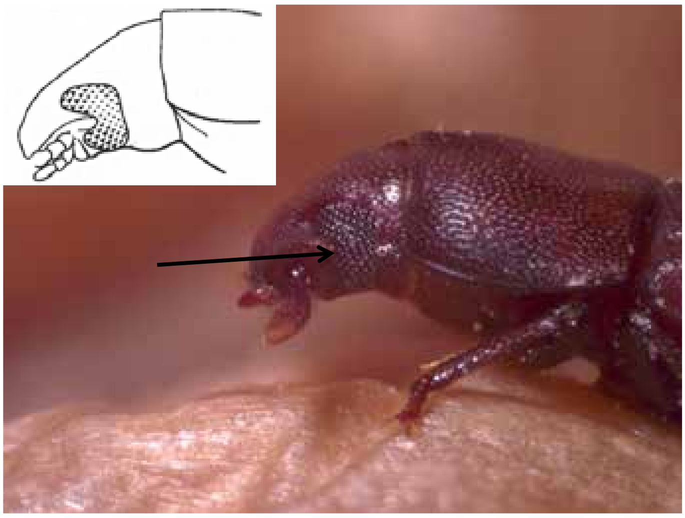


Figure 14.7.

Red flour beetle
***Tribolium castaneum* – eye four facets wide at narrowest point.**

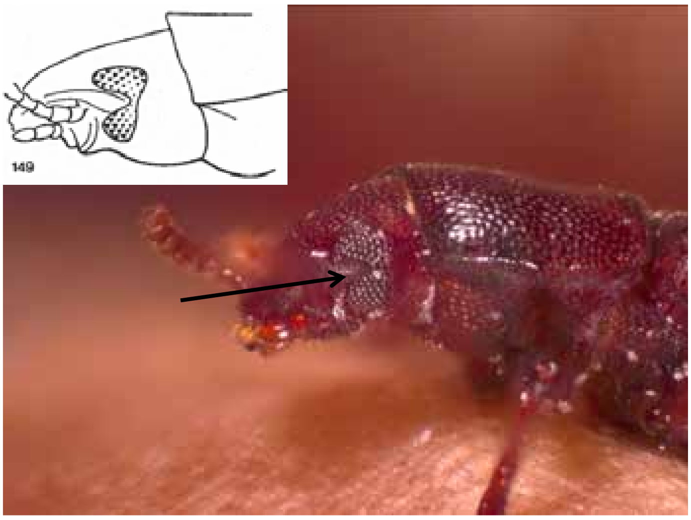


Figure 14.8.

Confused flour beetle
***Tribolium confusum*– eye two facets wide at narrowest point.**

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